CROSS EDUCATIONAL SOFTWARE
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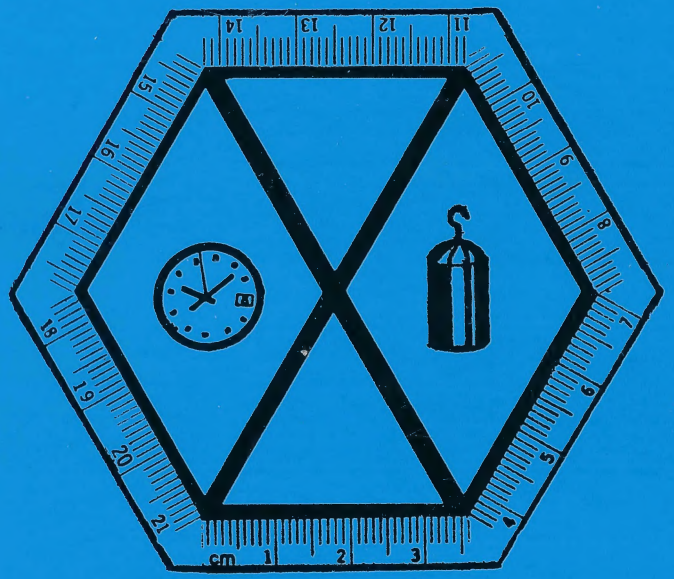
PHYSICS

VOLUME 8

OPTICS



CROSS EDUCATIONAL SOFTWARE

Computer Physics Series

O P T I C S

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INTRODUCTION

Volume eight in the college physics series has these six programs:

MIRROR RAY DIAGRAMS	WAVES
LENS RAY DIAGRAMS	DIFFRACTION
TYPES OF IMAGES	LASER

plus DEMUFFIN and other text and binary files used by WAVES, DIFFRACTION, and LASER. The ray diagrams were written by Steve Kamm, WAVES and DIFFRACTION were written by Paul Stephenson, and IMAGES and LASER are from Mark Cross.

This diskette uses Apple DOS 3.3. If you have an older disk drive with DOS 3.2 then you will have to BRUN DEMUFFIN to convert the whole disk. Take a blank diskette initiallized under DOS 3.2, plus this physics programs diskette, to a friend who has DOS 3.3. He will show you how to convert the programs to DOS 3.2.

MIRROR RAY DIAGRAMS

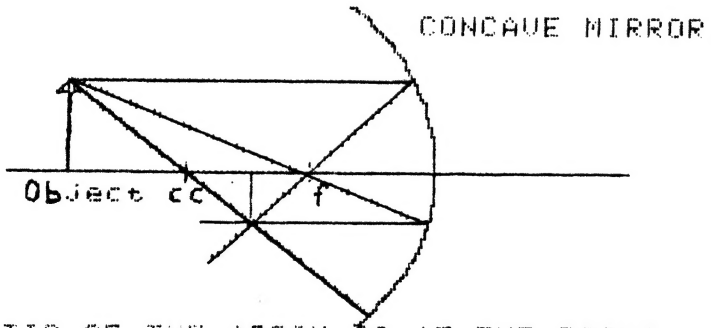
This program discusses three types of rays reflecting from concave and convex mirrors. It begins by discussing the terms concave, center of curvature, and focal point. Then it states these three rules:

1. A ray from the object through the center of curvature reflects back along itself.

2. A ray from the object point parallel to the axis reflects back through the focal point.

3. A ray from the object through the focal point reflects back parallel to the axis.

The program draws all three rays for a concave mirror. It chooses an object outside the center of curvature so the first ray will be easy to draw. An image is put at the point where the three rays intersect. Next, it draws the rays for a convex mirror and places the image. At its end the program recommends that the student try drawing for himself the case of a concave mirror with the object close to the mirror.



THE TIP OF THE ARROW IS AT THE POINT WHERE THE THREE RAYS INTERSECT.
THE TAIL OF THE ARROW REMAINS ON THE AXIS.
SEE HOW EASY IT IS, MARK!

<RETURN>

LENS RAY DIAGRAMS

This program builds on what the student has learned in "MIRROR RAY DIAGRAMS."

After some introductory remarks, a converging (convex) lens appears with focal points equidistant from it on both sides. The program places an object outside the focal point on the left side and then discusses three rays:

1. Ray 1 goes through the center of the lens. It is undeflected.

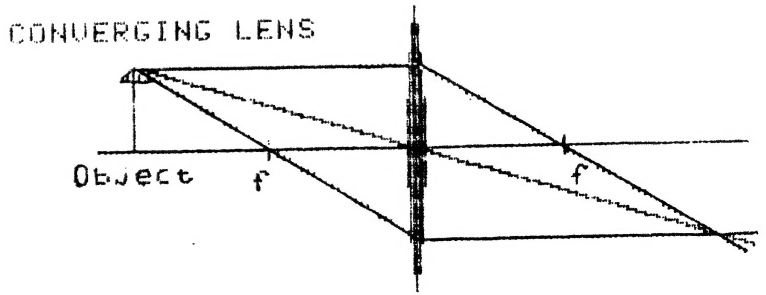
2. Ray 2 is parallel to the axis. After passing through the lens it bends towards the second focal point.

3. Ray 3 passes through the first focal point. When it passes through the lens it bends parallel to the axis.

The computer draws an image arrow with its tip at the intersection of the three rays.

Next, it draws the convex lens with an object arrow between the lens and the left focal point. It draws all three rays again and projects them backwards to find the virtual image. The student gets a chance to review at this time before going on to a diverging lens.

The computer uses the same three rules to draw rays passing through a diverging lens. It extends the rays to find the virtual image. Finally, it suggests that the student experiment with drawing the object in other positions.



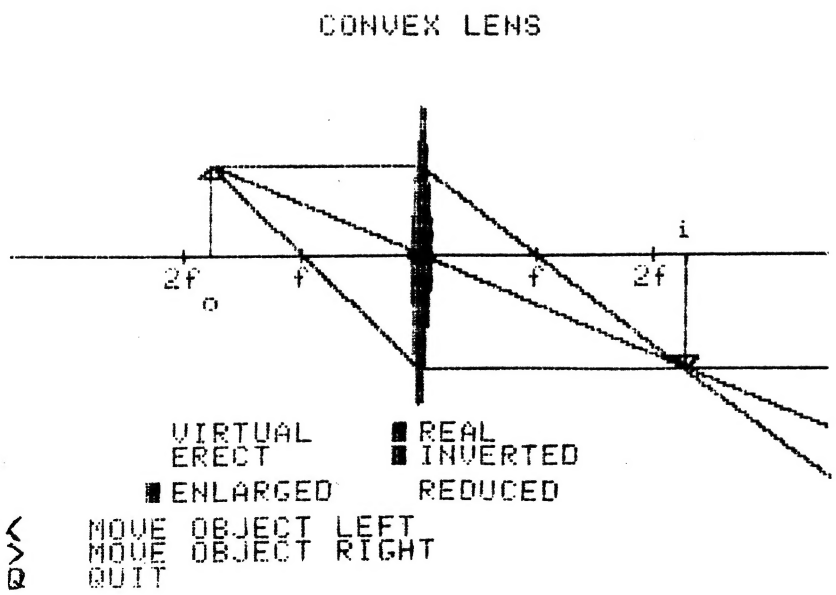
TYPES OF IMAGES

This is a computer experiment. It helps the student discover for himself the kinds of images that will occur when objects are placed at different positions in front of lenses and mirrors. He can select from this menu:

1. CONVEX LENS 2. CONCAVE LENS

3. CONVEX MIRROR 4. CONCAVE MIRROR 5. END

Each choice presents a picture similar to the one below. The student can move the object around by pressing keys. The rays are redrawn as the object moves. "REPEAT" will work to move the object faster if it is held down together with the left or right motion key. The program will return to the menu if "Q" is pressed to quit. Then the student can select another lens or mirror, or press "5" and exit the program.



HELIUM - NEON LASER

This program discusses "Light Amplification by Stimulated Emission of Radiation." Its menu has the items described below.

1. STIMULATED EMISSION discusses the difference between spontaneous and stimulated emission. It shows a light wave passing by an excited atom and becoming a double light wave.

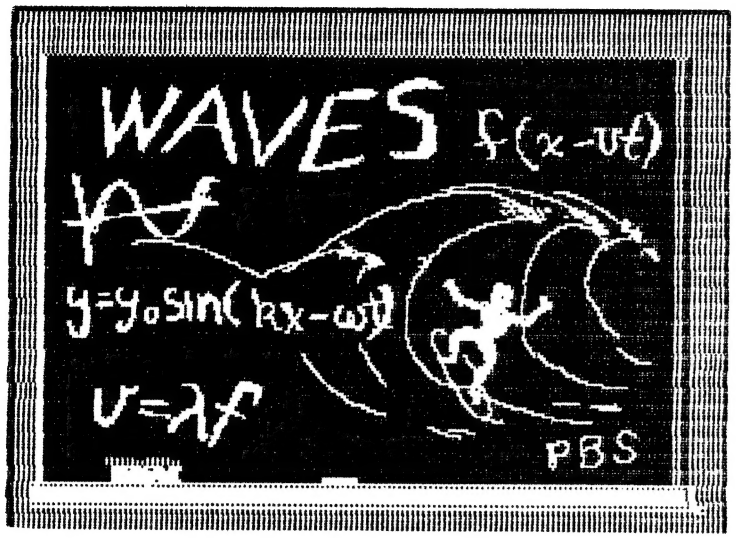
2. HELIUM AND NEON ENERGY LEVELS starts with a helium atom excited to its metastable state after a collision with another atom. Then it draws energy levels of a neon atom and transfers the energy to neon in a He-Ne collision. Finally, it shows light (6328 Angstroms) passing by the neon atom. The light is amplified while the neon falls to an intermediate energy level.

3. LASER CONSTRUCTION draws a large gas discharge tube with a few helium atoms inside it. The helium atoms become excited (dance around) because of the gas discharge. Then one neon atom is put into the tube. This emphasizes that the helium pressure is low, but the neon pressure is much lower. The program draws a smaller picture of a discharge tube like the one used in choice 4, laser operation. It shows a light wave passing by the neon and being amplified.

4. WATCH IT OPERATE. A pulse of light bounces back and forth inside a gas discharge tube containing red (helium and neon) gas. Under the pulse is a number between 20 and 99 labeled "LIGHT ENERGY." The energy increases as the pulse moves through the gas. The pulse loses some energy through the partially silvered mirror when it reaches the right side of the tube. The bouncing pulse can be speeded up by pressing "F" or slowed down by pressing "S" on the keyboard.

5. SEE THE WHOLE SHOW. This runs through all four of the choices.

6. QUIT leaves the laser program.



W A V E S

This program was written by an optics teacher to show the fundamental wave phenomena needed to study physical optics. The main menu has five items which are described below. All of these topics return the user back to the main menu when they are finished.

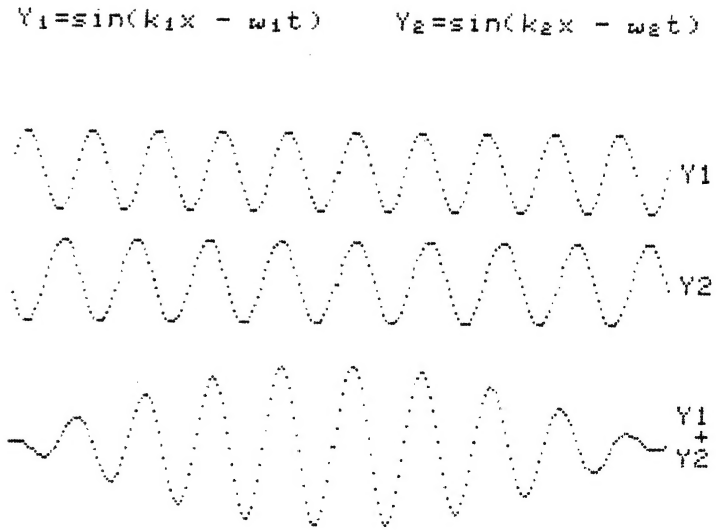
1. EXPLANATION OF SIMPLE WAVES gives about seven screens of text about wave functions: y = f (x-vt). Mixed in with the text are some multiple choice questions and demonstrations of wavelength, period, frequency, and a Gaussian wave function.

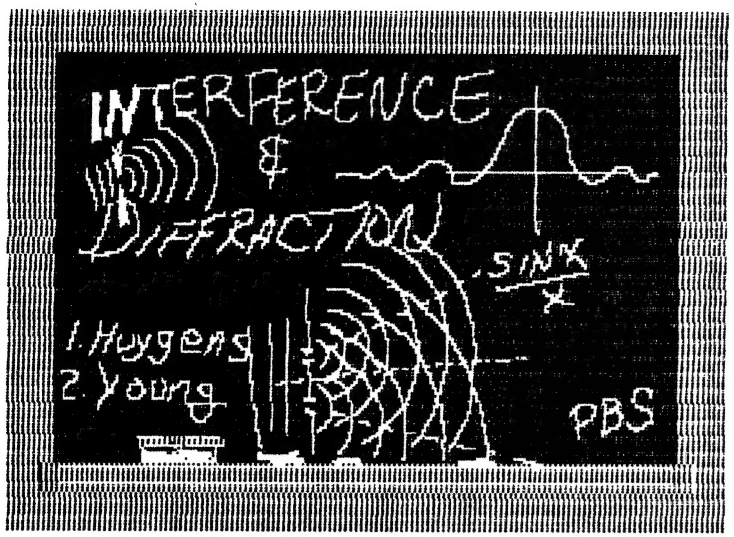
2. DEFINITIONS is a condensed single screen of definitions of wavelength, wave number, frequency, etc.

3. SUPERPOSITION OF WAVES has three choices: explanation, fast demonstration, and slow demonstration. The demonstrations send two waves across the screen from left to right. The screen dump (below) shows that the sum of the two waves appears at the bottom of the screen.

4. STANDING WAVES gives you the choice of an explanation or a fast demonstration. The demonstration has three waves on the screen: one going from left to right, another going from right to left, and the sum vibrating in place. The waves can be speeded up or slowed down. They can also be advanced at a single time step. This would make a good classroom demonstration. One third of the screen can be exposed at a time to demonstrate that the sum of two identical waves moving in opposite directions is a standing wave with double the amplitude.

5. COMPLEX WAVES are arbitrary functions which can be Fourier analyzed. The program can demonstrate four functions: square wave, sawtooth, wave packet, and a sum of frequencies input by the user. In each case the computer plots five partial waves across the top of the screen and builds up the sum at the bottom.





INTERFERENCE AND DIFFRACTION

This program is aimed at a college sophomore or junior taking an optics course. Its menu has six functions which are described below.

1. INTRODUCTION is two screens of text giving definitions and telling what the rest of the program can do.

2. TWO SLIT INTERFERENCE derives the formula for the phase difference between two waves coming through the slits and going on at some angle toward a distant screen.

3. MULTIPLE SLIT INTERFERENCE relies on what was taught in "two slit interference." There are six topics under this heading:

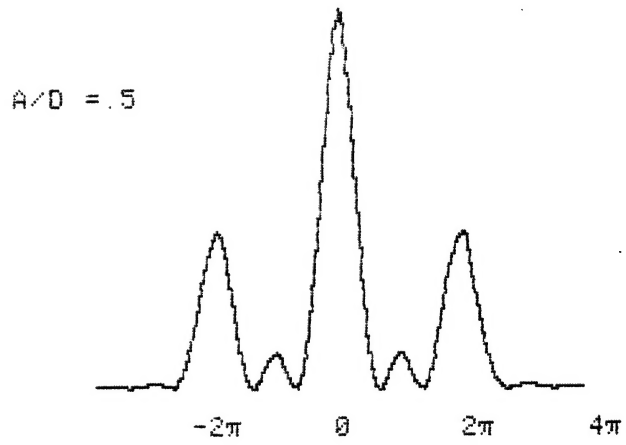
1. PHASOR REVIEW
2. TWO SLITS
3. THREE SLITS
4. FOUR SLITS
5. FIVE SLITS
6. MANY SLITS

Each topic shows how to use phasors to find the amplitude of the sum of the waves through the slits.

4. SINGLE SLIT DIFFRACTION sums up the waves from the many sources going across the slit, using phasors again.

5. PUTING IT TOGETHER involves both interference (from several slits) and diffraction (from wide slits). The program gives a demonstration with three slits having the width/spacing ratio = .5. Then the user can make another plot with his own number of slits and width/spacing ratio.

6. PHASOR CALCULATOR lets the user input the number of phasors and the phase angle between them. Then the program plots the resultant of the phasors and the intensity of the light wave.



Press any key...

PROGRAMMING NOTES

MIRROR RAY DIAGRAMS and LENS RAY DIAGRAMS are very similar. They originally were written to use the Mountain Hardware ROMPLUS board for their high resolution printing. They have been converted to draw their text on the high resolution screen from a shape table that has all of the ASCII characters.

The shape table is permanently appended to the last line of the program (63999). All the printing is done by defining a string M$="text ..." and then going to subroutine 10. This subroutine prints (draws) the string starting at cursor position CH, CV. The shape table is described in more detail in several other volumes of this series.

These two ray diagram programs are easy to read because their execution flows straight through from line 100 to 900 with very few branches to special subroutines.

TYPES OF IMAGES also uses the shape table described above. Its organization is more complex. Lines 10-35 are used to draw text on the screen. Lines 40-500 are subroutines that draw special rays for different situations in the lenses and mirrors. Lines 1000-1090 define special constants, print the menu, and get the user's command. Lines 1100-1300 control the convex lens; 2000-2200 the concave mirror; 2500-2700 the convex mirror; and 3000-3300 the concave lens.

W A V E S

This is a complicated program that uses several unusual programming tricks. It uses all the memory in a 48 K Apple and several disk files besides. Its machine language subroutines are so much faster than Apple's own high resolution plotting that waves can move across the screen in a good imitation of an oscilloscope.

Its memory management begins with machine language subroutines from 2048 up to 8192. It uses both high resolution screens from 8192 to 24576. The main program comes next, followed by variables and strings above the program. HIMEM: is set at 34816. Above all this is the high resolution character generator from Apple's DOS Tool Kit residing between 34816 and the disk operating system. All these modules are loaded and initialized by the command EXEC AUTO.

The WAVES program used all of available memory and then some. Many of its text explanations are stored on the disk and not called in until they are needed. See subroutine 16000 for the method of reading these text files. All print-out of the text files occurs with commands like "NZ$ = DES.1: GOSUB 16025". These text files are very difficult to change. The reading speed can be changed easily by putting a longer delay in line 16075 (between paragraphs) or line 16027 (printing speed of every character).

You can change and improve the program without too much trouble. Start by doing an FP and LOADing the WAVES program normally. Then list it and make the changes. Don't RUN the new program. Save it on the disk. Then EXEC AUTO, which will load and run the WAVES file from the disk.

WAVES prints everything with a high resolution character generator. There are two fonts included, standard English and Greek. Read the manual of the DOS Tool Kit for more information.

DIFFRACTION is similar to the WAVES program, but more complicated. DIFFRACTION uses all 48 K of memory and a web of interlocking subroutines. The command "EXEC AUTO.1" loads all of the machine language files, sets memory pointers, and runs the main program "DIFF".

FILES USED BY WAVES

```
A 044 WAVES (main program)
B 003 SINES
B 003 TWO.SINES.3
B 003 DENSE.PULSE.1
T 003 DES.3     T 002 AUTO
T 003 DES.4     T 005 DES.1
T 003 DES.5     T 005 DES.2
T 003 DEF.1     T 004 ST.1
B 003 DENSE.SINE
B 005 DENSE.SINES.1
T 003 ST.2      T 004 SUP.1
T 003 COM.1     B 034 ILLUS
B 033 TEM       B 034 TITLE
B 026 MACH.TWO
```

FILES USED BY DIFFRACTION

```
A 056 DIFF (main program)
T 002 AUTO.1
T 004 SM.2      T 005 SS.2
T 005 SL2.1     T 003 INTRO.1
T 004 SL2.2     T 005 REV.1
T 004 SL2.3     T 005 REV.2
T 004 SL2.4     T 004 REV.3
T 005 SM.1      T 003 DISP.1
T 005 SS.1
B 033 PIC.DIFF
B 026 MACH.TWO
```

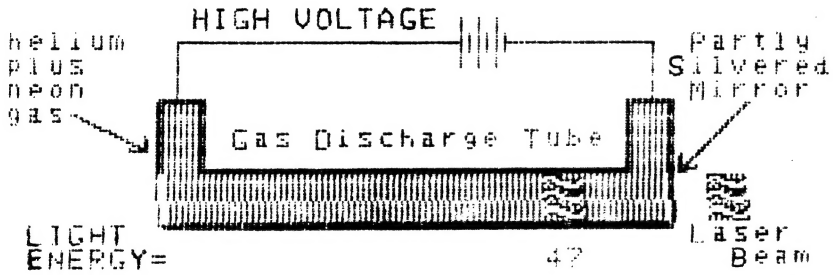
L A S E R

LASER is done entirely on the second high resolution screen. It uses the GRAPE printing system described in more detail in volumes two, three, and seven of this series. This printing system is stored in a separate file called "GRAPE.LASER". The file may be transfered to another disk by first BLOADing it and then: BSAVE GRAPE.LASER, A$7C00, L$19FF".

This version of GRAPE is very slightly modified with a few of the large special characters changed into atoms and light waves. Definitions of the special characters may be found in lines 60550-60650 of the program.

The program can end in two ways. An error or a control-C causes a jump to line 14900, which restores the standard text screen and stops the program. Choice six on the menu ends normally and runs the MENU program for the optics disk.

Helium-Neon LASER



COMMANDS: F = Faster S = Slower
M = Menu